CHEMICAL LITERATURE.

AN ADDRESS

DELIVERED BEFORE THE
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,
AT MONTREAL, AUGUST 23, 1882.

BY
PROF. H. CARRINGTON BOLTON, PH. D.
VICE PRESIDENT.

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AUTHOR'S EDITION.
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ADDRESS

BY

H. CARRINGTON BOLTON,

VICE PRESIDENT, SECTION C.

Fellow Members of the Chemical Section;

Ladies and Gentlemen:—

The recognition by the Association of the equal rights of chemical science and the elevation of the late "Permanent Subsection" to the dignity of a "Section of Chemistry," now assembled for the first time, mark an important epoch in the annals of our organization. Permit me to offer congratulations on our promotion and to express my high appreciation of the honor of presiding over your deliberations.

The Permanent Subsection of Chemistry was organized at the Hartford meeting of the Association in 1874. It had its origin in the action of a number of chemists assembled at Northumberland in August of the same year to commemorate Priestley's discovery of Oxygen. At that memorable gathering a discussion of the advantages of forming an independent organization in the interests of chemistry led to the appointment of a committee* "to cooperate with the American Association for the Advancement of Science at their next meeting, to the end of establishing a chemical section on a firmer basis."

This committee met at Hartford a few weeks later and united with the chemical members of the Association in founding a Per-

*The committee consisted of Profs. Silliman, Smith, Horsford, Hunt and Bolton.

manent Subsection in accordance with the provisions of the new constitution adopted at the same meeting. Meetings of the subsection were held on two days and arrangements were made for its permanent organization. In the following year the Association met at Detroit and the Subsection re-assembled under the chairmanship of Prof. S. W. Johnson. Before adjourning the section elected Prof. Geo. F. Barker chairman for the ensuing year and passed a resolution requesting the chairman-elect to prepare an address. This was the origin of the custom which it is my pleasant duty to follow. Professor Barker accepted the task and his masterly essay on the Atom and the Molecule (1876) is remembered by many in this audience. Since then Prof. F. W. Clarke (1878) has urged in your hearing the endowment of laboratories of research; Prof. Ira Remsen (1879) has magnified the claims of his chosen field of investigation — organic chemistry; and Prof. J. M. Ordway (1880) has gracefully surveyed the experiences of the past, the needs of the present and the prospects of the future of chemistry.

The amendments to the Constitution, adopted by the Association at the Cincinnati meeting, provide, as you are aware, for nine sections, each with its own presiding officer; since this may involve an equal number of annual addresses, it is hardly to be expected that each will maintain the elaborate character of those of former years.

I ask you therefore to bear this fact in mind while I invite your attention to a rather superficial survey of

CHEMICAL LITERATURE.

The literature of chemistry, extending as it does through a period of more than fourteen centuries, varies greatly in character, in province and in design; it partakes of the peculiar phases exhibited by the science at different epochs and depicts the experiences and thoughts of those who cultivated it in all ages. It may be studied from several points of view: the biographer searches the voluminous records to acquire knowledge of the intellectual activity of individuals; the historian unfolds the progress made by the science in a special field or in its entirety, with philosophical inquiries respecting effects and causes; the bibliographer, scarcely penetrating beyond the title pages of the dusty tomes, laboriously catalogues them to facilitate the researches of others.

We do not propose to give you a biographical, an historical or a bibliographical treatise, but rather to review chemical writings as sources of information and as portions of the world's literary productions. We shall concern ourselves less with the questions what were the personal history and life-work of a given author, and more with the queries what are the characteristics of the various classes of works at different epochs, what discoveries do they chronicle and what was their influence on the contemporaneous science.

The very earliest information concerning chemical arts comes to us from that ancient nation supposed by some to have given its own name to the science itself; not only do the sculptured tombs and temples of Egypt portray with unimpeachable authenticity and wonderful accuracy the technical skill of that venerable people, but these same monuments are even now relinquishing their hold on long-buried treasures in the form of papyri, whose perplexing script no longer conceals their meaning from the erudition of Egyptologists.

Of these miraculously preserved papyri the most valuable to chemistry is that discovered by Prof. George Ebers at Thebes in 1872, and named after its learned discoverer. We have described this elsewhere[1] and shall not here enter into details. It is the most ancient medical work extant, being assigned to the sixteenth century B. C., and contains a vast amount of information on the medical practice and the pharmaceutical preparations at that remote period. The unknown author wrote less obscurely than many of a much later date, and when the whole papyrus shall have been deciphered it will prove an invaluable contribution to chemical history.

The most ancient manuscript treating exclusively of chemical operations is a Greek papyrus of Egyptian origin preserved in the Library of the University of Leyden. Its authorship is unknown, its date is placed by Reuvens in the third or fourth century A. D. This MS. consists of a collection of prescriptions and receipts for conducting various operations in metallic chemistry, such as the testing of gold and silver; the purification of lead, of tin and of silver; the hardening of tin and of silver; the albification of copper, etc. It deals little with alchemy though some of the receipts evidently refer to transmutations, as those entitled: "the prepara-

tion (artificial?) of silver;" "the preparation of gold;" "the purification of tin by silver," etc.

Reference is made to sandarach (realgar), cadmia (zinc ore), chrysocolla, cinnabar, natron (soda), mercury and other chemical substances, but no receipts are given for their preparation. The author quotes from the Materia Medica of Dioscorides who probably preceded him by about two centuries. It is to be regretted that the full text of this ancient manuscript has never been published; the little known of it foreshadows information of great interest.[2]

The great libraries of Paris, Rome, Venice, Milan, Escurial, Cracow, Gotha, Munich and Cologne preserve a large number of Greek alchemical manuscripts of unknown authorship and uncertain date. Hoefer, the French historian of chemistry, refers them to the third and fourth centuries,[3] but other authorities with greater probability place them not earlier than the tenth and eleventh.[4]

The most celebrated of these essays are attributed to Zosimus, of whose history nothing is certainly known, and bear these titles: "On Furnaces and Chemical Instruments," "On the Virtue and Composition of Waters," "On the Holy Water," "On the Sacred Art of Making Gold and Silver." In a treatise attributed to Synesius, we find a description of a hydroscopium or hydrometer which was rediscovered as long after as the sixteenth century.

In a treatise attributed to Olympiodorus, he cites as authorities Democritus, Anaximander, Zosimus, Pelagius, and Marie a certain Jewess whom the later alchemists confounded with Miriam, Moses' sister.

In these manuscripts chemistry is called the "sacred art" and the exceedingly obscure and figurative language in which they are written makes it well nigh impossible to separate fact from fancy; Hoefer has indeed attempted to discover modern chemical conceptions in the allusions to Egyptian myths and the chaotic collections of spagyric arcana.

Of systematic nomenclature there is absolutely no trace; indeed each author seems to have aimed to write treatises intelligible only to himself, and we greatly doubt his success in even this respect. "Cadmia," we are informed, "is magnesia," and "magnesia is the female antimony of Macedonia;" "nitre is white sulphur which produces brass;" equally clear is the statement that the

"apospermatism of the dragon is the mercury of cinnabar." That lexicons were early in demand is not surprising; in fact some of the most ancient MSS. are "vocabularies of the sacred art," but even with their assistance it is difficult to form satisfactory concepts of contemporary chemical science.

Suidas,[5] a Greek lexicographer of the eleventh century, states that Diocletian having conquered the rebellious Egyptians (296 A. D.) destroyed their books on the preparation of silver and gold, lest becoming rich by the practice of that art they might again resist the Romans. Regrets at the wanton acts of this imperial biblioclast are tempered by the reflection that modern scholars are spared the study of such literary absurdities.

The Chinese, that curious people who always claim a hearing when the origin or antiquity of arts and sciences is under consideration, were acquainted at a very remote period with many branches of chemical technology. We do not know of any special chemical literature produced by them, but the researches of Rev. Joseph Edkins[6] and of Dr. W. A. P. Martin[7] make it highly probable that scholars will yet discover contributions of no small importance to the early history of chemistry. Prof. George Gladstone[8] has endeavored to show that the Chinese originated the doctrines and pursuit of alchemy and communicated it to the Arabians by whom it was disseminated throughout Europe.

The high state of civilization and extraordinary intellectual development of the Arabians has left a deep impression on chemical science. Cultivated chiefly by physicians, attention was directed to its pharmaceutical applications, and in spite of the prohibitions of the Koran to the fascinations of alchemy. Of their extant writings, preserved in European libraries, only a portion have been edited; those best known partake of the poetical imagery and hyperbole characteristic of the Oriental mind. This is shown to some extent in the singular titles prefixed to their treatises, *e. g.*, "The Rise of the Moon under the Auspices of Golden Particles," by the alchemist Dschildegi; "A poem in the Praise of God, of Mahomet and of Alchemy," by Dul-nun-el-Misri.[9]

The well known treatises of Geber,[10] "Of the Investigation of Perfection," "Of the Sum of Perfection," "Of the Invention of Verity," and "Of Furnaces," notwithstanding a bewildering style of composition, which seems to confirm Dr. Johnson's derivation of

gibberish, from Geber, display very great familiarity with a large number of chemical substances and operations.

Geber's works are generally assigned to the eighth century and consist chiefly of compilations from the "Books of the Ancients;" he mentions no author by name. They contain chapters devoted to the seven known metals, to the methods of distillation, calcination, cupellation and other operations, to the preparation of saline substances and to chemical philosophy. Geber adopted Aristotle's views of the constitution of matter from four principles, the hot and cold, the wet and the dry, and adds thereto: "Mercury and sulphur are the components of metals," a doctrine which with slight modifications prevailed for more than eight centuries. Geber describes the preparation of nitric acid, of aqua regia, and of mercuric oxide; he mentions the increase in weight of metals when calcined with sulphur, and gives the results of a rude quantitative analysis of crude sulphur. He constantly maintains the doctrine of transmutation of metals and gives a refutation of the ingenious arguments opposed thereto. His remarks on the qualifications of a chemist are most intelligent and are not inopportune in modern times; he urges the necessity of diligence, patience, learning, a temperate disposition, slowness to anger, and a full purse, "for this science agrees not well with a man poor and indigent," together with faith in the God who "withholds or gives to whom he will" the secrets of nature, and who will infallibly punish the foolish meddler with magical mysteries.

To detail fully our obligations to Arabian chemists is no part of our plan. They have left an indelible impression on the very language of the science, in the words alcohol, alembic, alkali, borax, and many others. All honor to the intelligent authors who a thousand years ago defined chemistry as the "Science of Combustion, the Science of Weight, the Science of the Balance!"[11]

In the middle ages intellectual activity was confined largely to the clergy, who controlled the schools of learning, the libraries, and nearly all sources of knowledge. University chairs were occupied exclusively by clerical professors[12], literature and science were cast in ecclesiastical moulds. Scientific treatises were the production of monks and emanated from cloisters. Many distinguished philosophers mastered widely separated branches of learning: among these were Alain de Lille (b. 1114), celebrated as a

physician, theologian, poet and historian, who filled the episcopal chair at Auxerre; Roger Bacon (b. 1214) an English cordelier; Raymond Lully (b. 1235), a Franciscan friar, and Albertus Magnus (b. 1193), Bishop of Ratisbon. The latter, amid the monotonous routine of a Dominican monastery, found leisure to distinguish himself in astronomy, medicine, alchemy and, according to his enemies, in necromancy. At this remote period, accusations of dealing with magic were not unfrequently made against those whose learning and skill in experimental sciences excited envy and superstitious zeal.[13]

To treat the writings of these eminent ecclesiastics as a part of chemical literature requires perhaps a stretch of the imagination, yet three hundred years ago they were regarded as masterpieces of the science and formed the text-books of students of alchemy. The writings of these ecclesiastical philosophers are as comprehensive as the branches of learning they cultivated, and incredibly voluminous; Albertus Magnus' collected works fill twenty-one folio volumes.[14] But a small fraction of these treatises are occupied with science and chemistry; and of this fraction there is in many cases a reasonable doubt as to their authenticity. In fact, nothing was more common than the ascription of work by an obscure second-rate writer to some celebrated philosopher of preceding ages, in order to give the work the stamp of authority,—a deception which previous to the invention of printing was more readily accomplished.

It became difficult therefore to distinguish the apocryphal writings from the genuine. The former, it is true, frequently betray themselves by anachronisms and other blunders, but many ingenious writers avoided such traps by adopting an enigmatical style worthy of the Delphian oracles.

Basil Valentine was the reputed author of works held in the very highest esteem by the alchemists of the Middle Ages, yet the very existence of this individual is seriously questioned. Mystery surrounds Valentine's entire history, and his writings were given to the world in a most dramatic manner; according to tradition they were hidden in the wall of a church at Erfurt and long after his death a thunderbolt shattered the wall and revealed the precious documents.

Whether Valentine was a real personage or not the works ascribed to him exhibit great familiarity with many chemical sub-

stances and operations, though the obscure and incoherent style renders their intelligent perusal very difficult.

Valentine's celebrated "Chariot of Antimony,"[15] extolling the medical virtues of this metal, is perhaps the least obscure of his works; the "Twelve Keys of Philosophy"[16] with its singular plates, one of the most unintelligible; yet beneath the extravagant jargon characteristic of the period, glimpses are obtained of light and intelligence. The latter work presents clearly the theory that all metals are compounded of three principles: fixedness, metallicity and volatility, represented respectively by salt, mercury and sulphur, an hypothesis which long completely controlled chemistry until it gave place to the seductive theory of Phlogiston. It is uncertain whether the works ascribed to Valentine were first written in Latin or in German; his writings were collected in the seventeenth century and have been through many editions.[17] Several of his treatises have been translated into English and into French.[18]

In the fifteenth century the newly invented printing press was employed in the production of few works which can be regarded as chemical, and these were chiefly confined to isolated treatises of the ancient philosophers; in the sixteenth century the alchemists began to publish the results of their industry and speculations, and in the succeeding century a prodigious number of alchemical works were issued in Germany, France and England, creating literature of an extraordinary type.

Some of these treatises, which are numbered by thousands, record valuable experiments made by enthusiasts seeking the philosopher's stone, but the majority contain "a crude mass of incoherent propositions and wild assertions, a mixture of poesy and insanity, in which all logical ideas are lost amidst the stilted phraseology, but through which breathed a blind yet fervent faith."[19] Great obscurity of style[20]; an enigmatical method of naming chemical substances which found its highest development in the use of arbitrary symbols and the pictorial representations of alchemical processes[21]; the intimate association with astrology; the honest or affected intermingling of pious comments and prayers[22]; the extravagant claims to antiquity as respects authorship and processes[23]; the attempts to interpret the mythology of Egypt and Greece on an alchemical basis; the endeavor to associate the mysteries of Hermes with the sacred truths of the Christian religion[24],— all combine to produce literary monstrosities as fascinating to the student of chem-

ical history as they are profitless to the practical worker in modern science.

Among the fabulous writings, highly esteemed by the credulous alchemists, may be mentioned the celebrated inscription of Hermes Trismegistus upon an Emerald Tablet[25], the Golden Leaves of Abraham, Jew Prince, Priest, Levite, Astrologer and Philosopher, which in the hands of Nicolas Flamel[26] yielded such a rich harvest, the Practical Chemistry of Miriam the sister of Moses[27], and a multitude of grotesque writings ascribed to personages of known reputation. Raymond Lully is credited with five hundred works; Hermes Trismegistus, the mythical Father of Sciences, with several thousand.

Many of the alchemical works published during the period of which we speak are degraded by admixture of the contemporaneous pseudo-sciences, judicial astrology and magic. To this class belong the celebrated works of Dr. Fludd and the writings of the Rosicrucians; excluding these as wholly beneath our consideration the number of occult works on alchemy is still very large. We imagine it will be hard to discover in the whole range of literature writings having scientific pretensions more senseless than the aphorisms of the disciples of Pythagoras, collected in the "Turba Philosophorum"[28] so often quoted by the alchemists of the sixteenth and seventeenth centuries. Its improbable character is perhaps equalled by the "Gloria Mundi" in which the anonymous author favors his readers with the chemical views of Aristotle, Plato, Socrates and Democritus, interspersed with equally authentic statements by Hermes and Morien, Lamech and Methuselah, Abel and Seth, and even of Adam himself.[29]

In the early part of the seventeenth century, Michæl Maier, physician to the Emperor of Germany, Rudolph II, a royal patron of astrologers and alchemists, published several treatises now much sought after by alchemical bibliophiles.[30] Maier's "Symbola aurea mensæ" and "Atalanta Fugiens" contain emblematic plates, supposed to illustrate the hermetic interpretation of the fables and allegories of Egypt and Greece.

The connection between these ancient mythologies and the secrets of the philosopher's stone was a favorite subject with many authors and has been exhaustively treated by the Abbé Pernety in his two curious works "Fables Egyptiennes et Grecques dévoilées" and "Dictionnaire Mytho-hermétique."[31] Not content with prose, several authors clothed their alchemical inspirations in poetry;

of these may be mentioned the Arabian treatises already named, the Twelve Gates of Alchemy by Sir George Ripley, written about 1450[32], the Crede Mihi of Thomas Norton, written about 1477[33] and the Chrysopœia of Aurelius Augurelli.[34] The latter written in Latin hexameters with more pretensions to elegance than usual with the prosaic alchemists was dedicated in 1514 to Pope Leo X. Leo rewarded Augurelli by presenting him with an empty wallet, remarking that one who knew so well how to make gold had need only of a purse.

The alchemists, in common with their contemporaries in other branches of literature, took pleasure in prefixing to their essays eccentric titles; Helvetius writes of "The Brief of the Golden Calf (The World's Idol) discovering the rarest Miracle in Nature;"[35] Glauber names one of his treatises, "The Golden Ass well managed and Midas restored to reason."[36]

Perhaps the height of absurdity is reached in the famous *Liber Mutus*[37], which consists of a series of fifteen symbolical engravings purporting to disclose the whole Hermetic Philosophy. The utterly unintelligible character of much alchemical literature is occasionally acknowledged by those who otherwise accepted the prevailing popular belief in transmutation; Lenglet du Fresnoy, speaking of Raymond Lully's Clavicula, says "Lully assures us that this treatise is indispensable to the comprehension of his writings; but, after reading it, one is little wiser than before."[38]

There are several large collections of alchemical treatises which the curious in these matters should consult; the most extensive is Zetzner's Theatrum Chemicum[39] published in 1613 in six octavo volumes; this contains no less than 209 distinct treatises, notwithstanding which Lenglet du Fresnoy remarks that many excellent ones are wanting. Manget's Bibliotheca Chemica Curiosa,[40] published in 1702 in two folio volumes, contains 133 treatises; and the Musæum Hermeticum[41] (1678) contains 21 treatises, some of which are illustrated. The most extensive English collection is Ashmole's Theatrum Chimicum Britannicum, published in 1652, and a noted French collection is Salmon's Bibliothèque des Philosophes Chimiques (1672), of which the edition by Richebourg (1741) is by far the best.[42]

Stimulated by avaricious hopes, the zealous alchemists labored most industriously; and, by subjecting mixtures of all known substances to heat and to the action of acids, discovered a multitude of new bodies having more or less medical and economic value.

As we have seen, their writings consist for the most part of monographs describing disconnected experiments, with no attempt at exhaustive treatment of any single topic, no classification of phenomena and no well studied arrangement of material such as characterizes later handbooks. Nor can a scientific collocation be expected during the formative period of chemistry and previous to the introduction of theories around which to group the isolated phenomena. One of the earliest attempts to treat chemical facts in a systematic manner was made by Sir George Ripley, Canon of Bridlington, who lived in the fifteenth century. In his "Compound of Alchemy" written in 1471 the whole science of hermetic chemistry is unfolded in a poem divided into twelve sections called "Gates" through which the reader is conducted to the mysteries of transmutation.[43]

"But into chapters thys Treatis I shall devyde,
In numbre twelve, with dew recapytulatyon;
Superfluous rehearsalls I lay asyde,
Intendyng only to give trew informatyon
Both of the theoryke and practicall operatyon:
That by my wrytyng who so wyll guyded be,
Of hys intente perfyctly speed shall he.

The fyrst chapter shall be of natural Calcination;
The second of Dyssolution, secret and phylosophycall
The third of our elementall Separation;
The fourth of Conjunction matrimonial;
The fyfth of Putrefaction then followe shall;
Of Congelation Albyficative shall be the sixt,
Then of Cybation, the seaventh shall follow next.

The secret of our Sublymation the eyght shall show;
The nynth shall be of Fermentatyon;
The tenth of our Exaltation I trow.
The elevent of our mervelose Multiplycatyon,
The twelfth of Projection; then Recapitulatyon,
And so this treatise shall take an end,
By the help of God, as I entend.

. . . . . .

Thus here the Tract of Alchemie doth end;
Which tract was by George Ripley, Chanon, penn'd.
It was composed, writt and signed his owne,
In anno twice seaven hundred seaventy one.
Reader, assist him, make it thy desire,
That after life he may have gentle fire! Amen.

Ripley's versification and theme remind one of Chaucer's Canon's Yeoman's Tale composed nearly one hundred years earlier.

We can only briefly allude to Paracelsus' bombastic productions[44], which are concerned chiefly with medical chemistry, and to the remarkable works of George Agricola[45], distinguished by profuse illustration, portraying the apparatus and operations of mining and metallurgy in the sixteenth century.

Conspicuous for accuracy of description and systematic arrangement of topics is the "Alchymia" of Andrew Libavius, published at Frankfurt in 1595.[46] Libavius, a physician and teacher in the gymnasium at Coburg, rejected the absurd doctrines of the adherents of Paracelsus, combated superstition and quackery and, excelling in observation of chemical phenomena, gained a worthy position among his compeers. In his Alchymia he treats of the *Encheria* or manual operations of chemistry and of the *Chymia* or descriptions of substances, in separate books. The former he divides into two sections, one dealing with the instruments and the other with the management of fires and construction of furnaces. He describes at length a sumptuous laboratory provided not only with every requisite for chemical experimentation, but also with means of entertaining visiting guests, including such luxuries as baths, enclosed corridors for exercise in inclement weather, and a well stocked wine-cellar.

Libavius was the discoverer of stannic chloride which still bears the name "fuming liquor of Libavius"; he describes the method of preparing artificial gems by coloring glass with divers metallic oxides, and he seems to have been the first to apply the balance to the examination of mineral waters. Notwithstanding his progressive position he devotes eighty pages of his Commentary to the Philosopher's Stone in which he was a firm believer. The second edition of his works, published in 1606, forms a folio of 800 pages. It has sometimes been called the First Text-book of Chemistry.

The "Tyrocinium Chymicum" (1608) of Jean Beguin[47], Almoner to King Louis XIII of France, a less pretentious work, is characterized by freedom from ambiguity and prolixity as well as from hermetic superstitions; it deals chiefly with the medical applications of chemistry.

In 1660, Nicolas le Febvre, demonstrator of chemistry at the Jardin des Plantes, published a "Traicté de la Chymie"[48] greatly superior to all preceding works of its kind. He collected the most reliable theories and experiments from all published sources

and arranged them in a logical, systematic manner. The first six chapters treat of the theory of chemistry; the author admits five elementary principles: phlegm (or water), spirit (or mercury), sulphur, salt and earth, the first three being ingredients of volatile substances, and the latter those of refractory bodies. He defines metals as hard bodies generated in the bowels of the earth, capable of extension under the hammer and of being melted by fire. He divides metals into the perfect and the imperfect, and also into male and female, the latter subdivision being based upon their behavior with acids; gold, lead and antimony are male metals because soluble only in aqua regia, and the other five, silver, copper, iron, tin and mercury are female, because soluble in unmixed acids.

In the second part the author discusses the manipulations of chemistry and recognizes many nice distinctions now overlooked; for example, under the head of mechanical division he describes in detail the following operations: "limation, rasion, pulverization, alcoholization, incision, granulation, lamination, putrefaction, fermentation, maceration, fumigation both dry and humid, cohobation, precipitation, amalgamation, distillation, rectification, sublimation, calcination both actual and potential, vitrification, projection, lapidification, extinction, fusion, liquation, cementation, stratification, reverberation, fulmination or detonation, extraction, expression, incineration, exhalation, digestion, evaporation, desiccation, circulation, congelation, crystallization, fixation, volatilization, spiritualization, corporification, mortification and revivification."

In the experimental part Le Febvre explains the arrangement in the following language:

"We shall begin with the meteoric bodies, rain, dew, honey, wax and manna; we shall then describe the preparations made from animals and their secretions; next, the numerous products of the vegetable world; and lastly, the mineral kingdom with its stones, salts, marcasites and metals;" a division still recognized.

The order in which he treats mineral chemistry is as follows: Earths; stones, precious and otherwise; metals; semi-metals, embracing mercury, antimony and bismuth; salts, including common salt, saltpetre, alum, sal-ammoniac and the vitriols; and lastly, the sulphuretted minerals, arsenic, etc. Under each division he gives precise instructions for numerous experiments upon these

substances and describes their medicinal value. The whole work is written in a clear style, free from affectation of mystery; it rapidly passed through five editions, and was translated into English and German.

Three years after the appearance of Le Febvre's Traité, his successor at the Jardin des Plantes, Christopher Glaser[49] of Basle, published a work having the same title also marked by special excellence.

The most successful handbook of the seventeenth century was undoubtedly the "Cours de Chymie" by Nicolas Lemery,[50] an eminent lecturer in Paris. The first edition of this work was published in 1675, and it reached the tenth edition before the close of the century; a fourteenth edition enlarged by Baron appearing as late as 1756. It was also translated into English (1677), German (1698), Italian (1763), and Spanish. The remarkable success of this work is due to a facility for describing dry facts with remarkable simplicity and accuracy. His style is more concise than Le Febvre's, and his arrangement of material shows a progressive spirit. The limits of this address forbid an analysis of Lemery's Handbook, which, moreover, is better known than some others to which we have granted fuller treatment.

Passing over a period of fifty years, the next complete compendium of chemical knowledge which we notice is the "Elementa Chemiæ" of Hermann Boerhaave, the celebrated professor of botany, chemistry and medicine in the University of Leyden. Boerhaave's great erudition, purity of style and brilliant eloquence attracted students in great numbers; such was the popularity of his lectures that "certain booksellers who aimed at lucre by the most scandalous means" published them in 1724, without his authority or consent; this "surreptitious edition"[51] contained, as Boerhaave himself complains, such "false, ridiculous and absurd things in every page," that he was compelled to publish his lectures in an accurate and complete form. Both editions were translated into English by Dr. Peter Shaw, and the authorized work passed through many editions in Latin, French and German.[52] Instead of attempting to give an analysis of two quarto volumes, we will quote Boerhaave's own account of his plan.

"My design," he says, "is to initiate students in the knowledge of chemistry; and to do this in the most effectual manner, I

shall give a clear methodical explication of all that is necessary for understanding the best authors and for performing the chief operations in this experimental art." After acknowledging the difficulty of a systematic treatment of "a science which has been cultivated rather by experiments at random than upon any regular principles, and by persons usually destitute of all . . . knowledge in the liberal arts;" he claims that "these obstacles may be surmounted by making a collection of the several effects, which the art has actually produced, justly deducing general rules therefrom and duly digesting the whole." He then explains the division of his work into three parts.

"The first will rehearse the origin, progress, cultivation and fortune of chemistry, . . ; the second part will deliver certain theorems or principles of chemistry; the third will exhibit the actual operations of chemistry, whereby bodies are changed agreeably to the rules of the art and to the end proposed therein." Boerhaave's sketch of the history of chemistry begins with the earliest times but seems to have been left incomplete; it is rendered useful by classified lists of chemical writings and numerous references.

In his treatment of the theory he departs somewhat from his plan and introduces material which really belongs to the third or practical part. Boerhaave introduces sections on the use of chemistry in natural philosophy, in medicine and in the mechanical arts; gives an exhaustive account of the wonderful nature of fire and experiments in heat, together with ingenious speculations concerning the heat of celestial bodies; he describes the various forms of chemical apparatus and the preparation of curious and useful substances from the vegetable, animal and mineral kingdoms. Boerhaave exhibited the spirit of a true philosopher and produced a work of extraordinary merit. He was quite free from the follies of alchemy, though he cautiously remarks that "we should always remember the limits of nature are by no means to be defined by us, things are taken for impossible which are only unknown by the ignorant" and "many things in chemistry are apparently more incredible than that lead should lose its natural form and be converted into gold." [53]

Contemporary with the systematic compilations of Libavius, Le Febvre, Boerhaave and others, were published hosts of independent works setting forth the results of prodigious labor in the chemical laboratory; many of these are filled with descriptions of

experiments made at haphazard, with no definite object in view, and having no necessary connection with each other.

Glauber's[54] voluminous writings, published in 1658, may be taken as an example of this class; in his works, amid controversies with Galenical physicians and curious apologies resulting therefrom, amid descriptions of alchemical mysteries and receipts for a universal panacea, amid extravagant praises of the "sal mirabile" (Glauber's salt), and curious narratives of personal history, we find many novel chemical facts having a medical or an industrial value. The whole is clothed in a very crude style with an affectation of secrecy and under capricious captions.

On the other hand, some of these treatises show signs of genius, especially in attempts to establish theories in explanation of the familiar yet astonishing phenomena; thus Van Helmont, whose contributions to medical chemistry we pass by, invented the word *gas* to aid in discriminating aeriform bodies[55]; and Rey, in his "Essays on the increase in weight of tin and lead when calcined[56]," demonstrated the weight of the air thirty years before the masterly researches of Boyle.

To attempt in this rapid review to do justice to the philosophical writings of the Hon. Robert Boyle is a hopeless undertaking. From his first publication, in 1660, "New experiments, physico-mechanical, touching the spring of the air and its effects," to his posthumous treatise "Medicinal Experiments," published in 1692, his works teem with ingenious experiments described with great candor and fidelity, and from which conclusions are drawn with cautious reserve and philosophical soundness, as admirable as his rare modesty.

In his "Sceptical Chymist" (London, 1661), Boyle raises doubts as to the elementary nature of earth, air, fire and water, as well as of the alchemical principles, sulphur, salt and mercury, and claims that the first elements of bodies are atoms of different shapes and sizes, the union of which forms what are vulgarly called elements; he argues that their number should not be confined to three nor four, but that probably a large number of primary constituents would eventually be separated or isolated as such. He also first clearly recognizes the distinction between mixture and chemical combination.

The rejection of Boyle's prophetic hypothesis by his contemporaries much retarded the progress of the science. "More, how-

ever, than for his views on the nature of the elements, science is indebted to Boyle for his clear statement of the value of scientific investigations for its own sake, altogether independent of any application for the purposes either of the alchemist or of the physician . . Boyle was in fact the first true scientific chemist, and with him we may date the commencement of a new era for our science when the highest aim of chemical research was acknowledged to be the simple advancement of natural knowledge." (Roscoe.)

Boyle's voluminous writings were collected by Birch in five folio volumes and published in 1744. His diffuse style of composition, with frequent long digressions, renders a perusal of his writings wearisome and led to an edition by Dr. Shaw, in which his works are "abridged, methodized and disposed under general heads," forming three quarto volumes bearing the date 1725.[57] Many of Boyle's papers were published in the Philosophical Transactions.

The literature pertaining to the theory of phlogiston belongs almost wholly to the eighteenth century. It is true that Becher's Physica Subterranea was published in 1659[58], but the theory of a combustible principle existing in all metals remained dormant until Becher's admirer, George Ernest Stahl, published an edition of the Physica Subterranea in 1702; to this he prefixed a long preface elaborating those doctrines which exerted such immense influence on both the theoretical and practical science, for more than a century. The writings of Becher and Stahl are notorious for their barbarous mixture of poor Latin and German, for which indeed both authors apologize.[59]

In Mayow's Treatise on the nitro-aërial spirit[60], we find records of admirable experiments in pneumatic chemistry supported by accurate reasoning and almost prophetic insight of later theories of combustion, but his early death prevented the continued support of his views, and Mayow's treatise was soon forgotten by the prejudiced followers of Stahl.

In the year 1683 a noteworthy event occurred in the chemical world, the opening of public laboratories of instruction. Chairs of chemistry had long existed in institutions of learning, the first being filled nearly eighty years before by Johann Hartmann, and the honor belonging to the University of Marburg. Practical in-

struction had been secured also in the private laboratories of the wealthy, thus Homberg and Friedrich Hoffmann worked in Boyle's establishment[61]; but the first public laboratory for instruction was opened at Altdorf, Bavaria, under the direction of Prof. J. M. Hoffmann. A survey of the status of chemical knowledge at that date offers a tempting digression but the length of this address forbids.

The second public laboratory was opened in the same year (1683) at Stockholm, under the patronage of Karl XI of Sweden, and under the guidance of Urban Hiärne. Both institutions issued publications bearing the general title Acta[62] which may be regarded as forerunners of the "Contributions from the Laboratory of ——— University" now so common in periodical literature.

Lexicons and dictionaries have been a feature of chemical literature from the earliest times; we have already alluded to the vocabularies of the sacred art found among the Greek MSS. of the Paris National Library and referred to the tenth and eleventh centuries. These, however, seem to have been compiled for the purpose of misleading the novice in alchemical mysteries, and as Hoefer justly remarks themselves need commentaries to become intelligible.

The universal employment of symbolic characters, to represent both chemical substances and operations, rendered alchemical literature difficult of perusal and early led to the publication of keys and vocabularies explaining them. Such keys occur in the manuscripts just mentioned, in Eschenreuter's "Universal Panacea for Men and Metals"[63] which purports to have been written in or before the fourteenth century, and in the works of Oswald Crollius[64], Kircher[65], Le Febvre, Lemery and many authors of the seventeenth century: these however are not properly dictionaries.

Dr. Martin Ruland, court physician to Rudolph II, published a "Lexicon alchemiæ" in 1612, and William Johnson[66] a "Lexicon chymicum" in 1657, but the first really satisfactory treatment of chemistry in monographs alphabetically arranged was by Macquer[67] whose "Dictionnaire de Chymie," published in 1766, had great success, passing through several editions and being translated into the German, English, Italian, Spanish, Danish and Russian languages.[68] Macquer found many followers, among whom

may be mentioned Nicholson (1795), Cadet (1803), and well known authors whose works are indispensable to all students of the science.

Prof. Wm. Ripley Nichols, of Boston, late chairman of this Section, in a recent private communication, has expressed the need of yet another dictionary, one of chemical synonymes. He calls attention to the large number of names by which certain chemical substances have been known at different epochs and in different professions, and to the utility of a dictionary explaining their synonymy. Professor Nichols suggests "restricting the list to terms found in the literature of the preceding hundred years, but including such alchemical names as have peculiar historic interest and such as have persisted more or less in commerce and pharmacy." He also suggests that the work should include English, French and German names, except when they are simply literal renderings of the same term, and names of those minerals which are of simple composition like halite, witherite, fluorite, etc., under their appropriate heading. In an example of the proposed method of treatment he gives a long list of names for ferric oxide under the several heads: alchemical, chemical, mineralogical, pharmaceutical, commercial and popular.

The idea is certainly excellent and we have Professor Nichols' permission to mention it publicly in the hope that some one may be incited to compile such a work. We are not aware of the existence of any modern chemical synonymicon, not having seen Berta's Dictionary of chemical terms[69], published at Padua in 1842; perhaps the nearest approach to the ideal work of Professor Nichols is Sommerhoff's Lexicon pharmaceutico-chymicum[70], published in 1701, a folio of 400 pages.

About the middle of the seventeenth century the dissemination of the views of Lord Bacon, as expressed in his *Novum Organon*, gave a great impulse to scientific investigations, and the "splendid fiction of the new Atlantis" was practically realized in the foundation of the "Royal Society for improving Natural Knowledge." The learned men, who in 1645 met in London, and there disturbed by unhappy dissensions of civil war withdrew to Oxford to report and discuss philosophical experiments, laid the foundations of an edifice destined to rise higher, endure longer and to shelter a nobler offspring than the most sanguine could have foreseen. The organization was granted a charter by King Charles II in 1662 and

three years later began the publication of the "Philosophical Transactions, giving some accompt of the present undertakings, studies and labours of the ingenious in many considerable parts of the world." In the following year the French Academy of Sciences began their Mémoires. Thus arose the element of periodicity in scientific literature, one which rapidly increased in importance.

The year 1665 also witnessed the birth of the parent of that large class of periodicals not issued by societies but published by private parties either individually or coöperatively. The first number of the "Journal des Scavans" appeared January 5, 1665, and for one hundred and thirty years was the most prominent literary and scientific journal of Europe. At that early date the periodicals partook of a literary nature rather than of the scientific, but gradually these two elements became distinct and the lines became more and more closely drawn until every branch of pure and applied science supported a serial especially devoted to its progress. Among the earliest periodicals devoted to chemistry and its associate physics may be mentioned the "Journal de Physique et de chimie," edited by the Abbé Rozier, de la Méthérie and others, begun in 1770 and continued through ninety-five volumes to 1822; the "Chemisches Journal" of Lorenz Crell, 1778–86, which was followed by the "Chemische Annalen" by the same editor, extending until 1803. The "Annales de Chimie et de Physique," begun in 1789, enjoys the honor of being the oldest surviving serial of this class.[71]

Of the foundation of Societies exclusively devoted to chemistry in France, England, Germany and America, and of their periodical publications, we can make mere mention. The existence of a "Columbian Chemical Society" in Philadelphia, as early as 1811, deserves passing notice. Two volumes of its Memoirs were published containing articles by Drs. Mitchell, Cutbush, Manners, Bache and others.

Of chemical bibliography and works relating exclusively to the history of the science, we have elsewhere[72] given a critical résumé.

As we proceed with this review of chemical literature, the publications increase enormously in number, variety and importance, and the end of our undertaking seems to move forward faster than we progress. It is manifestly impossible in the brief time allotted to this address to analyze the chemical literature of the preceding hundred years. How shall we attempt to portray the

theories and experiments recorded in the writings of Bergmann[73], Scheele[74] and Gahn, the eminent Swedes; of Black[75], Cavendish[76] and Priestley[77], the English triumvirate; of the French philosophers Fourcroy[78], de Morveau[79], and Lavoisier[80]; of the industrious German chemists Kunckel[81], Marggraf[82], Wenzel[83], Klaproth[84] and Richter[85]; or of the Italian philosophers Galvani[86], Volta[87], and Brugnatelli?[88] And passing to a later period, how shall we do justice to the labors of Berthollet[89], Gay Lussac[90], Thénard[91] and Laurent[92]; of the immortal Dalton[93], of the brilliant Davy[94] of the indefatigable analyst Berzelius[95]; of Mitscherlich, Liebig, Wöhler, and Hoffman; of Dumas, Berthelot and Adolph Wurtz; of Graham, Frankland, Abel and Crookes?

American contributions to chemical literature have been exhaustively discussed in the hearing of many present and need not now detain us; I refer to Prof. Silliman's Address at the celebration of the centenary of Priestley's discovery of Oxygen, held at Northumberland in 1874.[96]

The modern period of chemical literature is characterized by two opposing forces, a tendency to dispersal and an effort to collect the widely scattered publications. The multiplication of learned societies especially in Europe, each of which supports its own organ, and the increasing number of nations interested in scientific pursuits, in each of which arises an independent periodical, tend to the wide dispersal of memoirs, essays and notices.

On the other hand, industrious editors laboriously collect and set in order these scattered observations, constructing compact, massive handbooks and many volumed cyclopedias. The monumental work of Gmelin, which is even now passing through another edition, has worthy rivals in the magnificent compilations edited by Henry Watts and by Adolph Wurtz, and in the work of Beilstein in a field of special difficulty. For systematic treatises we can point to Miller, Graham-Otto, Pelouze et Frémy, Roscoe and Schorlemmer and the ever youthful Fownes.

Invaluable, too, are the annuals known as Jahresberichte, monuments of conscientious editorship.

Another feature of modern growth is the multiplication of special treatises dealing with single topics in every branch of chemistry, inorganic, organic, theoretical, analytical, technological, pharmaceutical and physiological, until mere acquaintance with their titles

becomes a serious undertaking for busy workers in the laboratory.

The amount of time and labor required to search for a given point throughout the maze of modern chemical journals, transactions, treatises and hand books, is well appreciated by my audience; the superb dictionaries and annuals referred to accomplish much in cataloguing, condensing and systematizing the infinity of observations; nevertheless, all working chemists feel the need of special indexes, simply arranged, as complete as possible and accessible to every one. Sharing in this feeling, I have contributed my mite to the literature of chemical indexes and have inspired several friends, fellow-members of this Association, with the courage to follow. Uranium[97], Manganese[98], Titanium[99], Vanadium[100], Ozone[101], and Peroxide of Hydrogen[102] have been indexed on a uniform plan, and my pupil W. W. Webb, B. S., has prepared an Index to the Literature of Electrolysis[103], which will soon be published in the same channel as the others;— the Annals of the N. Y. Academy of Sciences.

Pardon, we beg you, these personal allusions: we have indulged in them with the object of bringing before this Section a proposition for organized effort in the preparation of Indexes to all the Elementary Substances on a uniform plan.

The advantages which would accrue from the publication of special indexes to the literature of the elements and of such other subjects as may prove desirable are too obvious to need argument; I have thought that the undertaking might be placed in the hands of a Committee of the Chemical Section of this Association. The existence of an Index Society in England under the guidance of Henry B. Wheatley, F. S. A., Hon. Sec.,[104] affords a precedent, if indeed any be required.

The first duty of the Index-Committee of the Section of Chemistry would be to secure volunteers willing to undertake the compilation of special indexes; surely in this National Association a few chemists can be found ready to coöperate in such an important work. The Committee would further adopt a uniform plan for the indexes, determine the method or channel of their publication, and exercise general editorial supervision over the undertaking.

Hoping that this suggestion will receive your approbation I leave it in your hands.

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